# **BMJ Open** Predicting mortality and morbidity in emergency general surgery patients in a Jordanian Tertiary Medical Center: a retrospective validation study of the **Emergency Surgery Score (ESS)**

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# ABSTRACT

**Objective** The Emergency Surgery Score (ESS) is a predictive tool used to assess morbidity and mortality rates in patients undergoing emergent surgery. This study explores the ESS's predictive ability and reliability in the Jordanian surgical population.

Design A retrospective validation study.

Setting A tertiary hospital in Jordan.

Participants A database was created including patients who underwent emergent surgery in King Abdullah University Hospital from January 2017 to June 2021. Primary and secondary outcome measures Relevant preoperative, intraoperative and postoperative variables were retrospectively and systematically gathered, and the ESS was calculated for each patient accordingly. In addition, a multivariable logistic regression analysis was

performed to assess the correlations between the ESS and postoperative mortality and morbidity along with intensive care unit (ICU) admissions.

**Results** Out of total of 1452 patients evaluated, 1322 patients were enrolled based on inclusion and exclusion criteria. The mean age of the population was 47.9 years old. 91.9% of the patients were admitted to the surgical ward through the emergency department, while the rest were referred from inpatient and outpatient facilities. The mortality and postoperative complication rates were 3.9% and 13.5%, respectively. Mortality rates increased as the ESS score gradually increased, and the ESS was evaluated as a strong predictor with a c-statistic value of 0.842 (95% CI 0.743 to 0.896). The postoperative complication and ICU admission rate also increased with reciprocal rises in the ESS. They were also evaluated as accurate predictors with a c-statistic value of 0.724 (95% CI 0.682 to 0.765) and a c-statistic value of 0.825 (95% CI 0.784 to 0.866), respectively.

Conclusion The ESS is a robust, accurate predictor of postoperative mortality and morbidity of emergency general surgery patients. Furthermore, it is an allimportant tool to enhance emergency general surgery practices, in terms of mitigating risk, guality of care measures and patient counselling.

# STRENGTHS AND LIMITATIONS OF THIS STUDY

- $\Rightarrow$  An external validation of the Emergency Surgery Score in Jordan.
- $\Rightarrow$  The data sample is well distributed in terms of patients' demographic characteristics and surgical approach.
- $\Rightarrow$  An insight into the nature of emergency general surgery in a hospital that receives referrals from the region and whole of Jordan.
- $\Rightarrow$  The retrospective nature of the data collected for the study is a limitation.
- $\Rightarrow$  Our definition of emergency surgery and practice protocols may differ from other healthcare providing establishment given the nature of resources available.

# INTRODUCTION

≥ Emergency general surgery (EGS) includes training, an assortment of pathologies linked by their urgency and accounts for an increasingly large share of overall patient populations.<sup>1</sup> Patients requiring EGS have a substantial rise in 30-day mortality and postoperative <u>0</u> complication rates when compared with elective surgery patients.<sup>2</sup> Such upsurge has been credited to clinical and patient factors the time of surgery such as age, comorbidities and acute physiologic disturbances. Thirty-nine per cent of EGS patients are **g**. probably going to die within 30 days postoperation, with EGS being found to be an independent risk factor.<sup>3</sup> With the increase in EGS, public health and financial repercussions may result, highlighting its burden on healthcare systems.<sup>45</sup> The Acute Care Surgery (ACS) model has been created to benefit safe and efficient care of trauma and EGS, with an initiative joining trauma, critical care and EGS demonstrating better results in the

data mining,

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Table 1     Emergency Surgery Score (ESS) variab	les
Variable	Points
Demographic	
Age >60 years	2
White Race	1
Transfer from outside emergency department	1
Transfer from an inpatient facility	1
Comorbidities	
Ascites	1
Body mass index (BMI) <20 Kg/m <sup>2</sup>	1
History of disseminated cancer	1
Dyspnoea	3
Functional dependence	1
History of chronic obstructive pulmonary disease	1
Hypertension	1
Steroid use	1
Preoperative ventilator requirement >48 hours	3
Weight loss more than 10% in the last 6 months	1
Laboratory values	
Albumin <3.0 U/L	1
Alkaline phosphatase >125 U/L	1
Blood urea nitrogen >40 mg/dL	1
Creatinine >1.2 mg/dL	2
International normalised ratio >1.5	1
Platelets <150×10 U/L	1
Aspartate aminotransferase (AST; SGOT) >40 U/L	1
Sodium >145 mg/dL	1
White blood cells x 10/L	
Less than 4.5	1
More than 15 and less than 25	1
More than 25	2
	Maximum score of ESS=29

management of appendicitis and biliary disease.<sup>67</sup> The model's success relies on guidelines, benchmarks and quality improvement processes. Nevertheless, EGS is deficient in benchmarking and quality enhancement, and in light of its healthcare burden, there is a need for standardisation of patient care.<sup>8</sup>

It is important to be able to predict postoperative results in EGS patients in order to facilitate proper bedside decision-making and optimise postoperative care. The Emergency Surgery Score (ESS) has been derived to predict mortality and postoperative complications after EGS, calculated by summing specific points to 22 distinct demographic, comorbidity and preoperative

laboratory variables for a maximum of 29 points.<sup>9 10</sup> The ESS has been retrospectively validated that has confirmed its efficacy as a pre-operative risk score.<sup>11-13</sup> The score has also been reported to accurately predict the development of postoperative infectious complications and can be used as a preoperative tool to assess the suitable level of care after surgery.<sup>14 15</sup> Moreover, it has been ratified prospectively, reinforcing its role as a bedside tool to help surgeons counsel patients and their families, and as an intensive care unit (ICU) triaging tool if critical care capacity is limited.<sup>16</sup> As ESS is specific to EGS, the previously mentioned studies help to verify its use as a tool to benchmark the quality of service and care.<sup>13–16</sup>

External score validations are extremely valuable to 8 assess differentiation and standardisation in other populations, as well as increase global awareness of applicable predictive models.<sup>17</sup> To date, only a couple of such validations exist, focusing on different domains within the ESS predictive capability.<sup>12 18</sup>

In low and middle-income countries, surgical emergencies define most emergencies and have been estimated to cause a tremendous health burden.<sup>19</sup> Variance in access to surgical care and a growing volume of unmet surgical uses rela needs delineate the broad difference between low and high-income countries. In Jordan, emergency surgery is actively stressing our capacity to care for our patients and are adding to the financial load in our healthcare system. As the COVID-19 pandemic plays an active and disruptive đ role in the change in current surgical practice around the e world, the effect is prominent in Jordan.<sup>20</sup> Validating the ESS in our population is a step towards improving bedside decision-making and postoperative care, as well as a tool to enhance triaging EGS patients and help curtail the đ onus of emergent surgery. Our study will allow us to estimate the postoperative mortality and complication rates, in addition to assess the ability to predict them through ESS.

# **METHODS**

ig, Al training, and A database was created using the electronic medical record system at King Abdullah University Hospital (KAUH), a tertiary hospital serving northern regions in Jordan. We identified all patients that were admitted to the general surgery ward for emergency surgery from January 2017 to June 2021. All adult patients 16 years of age and older presenting to the ER for general surgery and operated on were included. This includes patients operated on for thoracic, hepatobiliary, upper gastrointestinal, colorectal, vascular, breast and endocrine, trauma and soft tissue pathologies. Patients under 16 years old, pregnant, patients that we treated conservatively, patients that voluntarily refused treatment against medical advice, patients referred from clinic visits or admitted electively were excluded from the study. In addition, an emergent surgery was defined in line with the ACS-NSQIP (Amercian College of Surgeons- National Surgical Quality Improvement Program) definition as an

Table 2 Patient demographics								
Age in years	Number of patients (N (n%))	Mortality rate (N (n%))	Postoperative complication rate (N (n%)					
Age								
16–17	15 (1.1)	0 (0.0)	0 (0.0)					
18–19	21 (1.6)	0 (0.0)	0 (0.0)					
20–29	175 (13.2)	0 (0.0)	14 (8.0)					
30–39	205 (15.5)	1 (0.5)	14 (6.8)					
40–49	289 (21.9)	7 (2.4)	30 (10.4)					
50–59	297 (22.5)	15 (5.1)	54 (18.2)					
60–69	166 (12.6)	11 (6.6)	29 (17.5)					
70–79	115 (8.7)	11 (9.6)	27 (23.5)					
>80	39 (3.0)	7 (17.9)	10 (25.6)					
Gender								
Male	696 (52.6)	27 (3.9)	106 (15.2)					
Females	626 (47.4)	25 (4.0)	72 (11.5)					
Admission source								
Emergency room (ER)	1215 (91.9)	44 (3.6)	153 (12.5)					
Referred from outside ER	90 (6.8)	6 (6.7)	21 (23.3)					
Referred from inpatient facilities	17 (1.3)	2 (11.8)	4 (23.5)					
Surgical approach								
Laparotomy	762	49 (6.4)	157 (20.6)					
Laparoscopy	560	3 (0.5)	21 (3.75)					

emergency case that is 'performed within a short interval of time between patient diagnosis or the onset of related preoperative symptomatology'.<sup>21</sup>

We calculated the ESS for each patient as described by Sanji *et al*<sup>p</sup> (table 1). For each patient, demographic, preoperative laboratory and comorbidities were retrieved from the electronic medical system. Data collection included the following preoperative variables: age, nationality, whether the patient was transferred from an outside emergency department or transferred from a primary hospital inpatient facility, body mass index (BMI), history of disseminated cancer, hypertension, diabetes mellitus, steroid use, ascites, dyspnoea, ascites, history of chronic obstructive pulmonary disease (COPD), functional dependence, ventilator requirement within 48 hours preoperatively, weight loss in preceding 6 months. In addition, we also recorded the following lab values: albumin, alkaline phosphatase (ALP), blood urea nitrogen, creatinine, international normalised ratio (INR), platelets, aspartate transaminase (AST; SGOT (spartate aminotransferase)), sodium, white blood count. Other variables included diagnosis leading to the admission, the incidence of postoperative complications, the need for ICU admission, and hospital length of stay if the patient was reoperated for the same cause, and outcome of the admission including whether the surgical intervention led to resolution of the acute condition.

All included patients identified as Jordanian and thereby considered as non-white and received a corresponding score of zero. For any missing variable, the null score value was used, and zero points were given, as previously described by Naar *et al*, in which the predictive capability of the ESS was not affected by the inclusion of patients with any missing data.<sup>22</sup> The lowest capture rate per variable was albumin, INR/prothrombin time (INR/PT), ALP and AST (41.53%, 60.28%, 41.81%, 41.25%, respectively).

Our validation aimed to study the score's ability to predict mortality, the incidence of any complication after surgery, admission to ICUs, and whether the patient was reoperated for the same admitting diagnosis. The aforementioned postoperative outcomes were observed over a 30-day period beginning at the time of surgery.

All the variables were recorded and presented as frequencies and percentages. The Shapiro-Wilk test was used to assess the distribution of the data across the age groups. The score validity as a predictor of mortality, postoperative complication and ICU admission was evaluated by performing multivariant logistic regression that included all ESS variables. After determining mortality and complication rate per score, the receiver operator characteristic and area under the curve was calculated and compared with the American Society of Anesthesiology physical status classification system (ASA), which

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#### Patient outcome data Table 3 Number of patients (n (n%)) ASA grade 684 (51.7) 1 2 319 (24.1) 3 222 (16.8) 4 95 (7.2) 5 2 (0.2) Diagnosis leading to the admission Acute cholecystitis 347 (26.2) 108 (8.2) Infected diabetic foot Obstructive jaundice 98 (7.4) Acute lower limb ischaemia 86 (6.5) Acute appendicitis 85 (6.4) Thrombosed AV fistula 52 (3.9) Large bowel obstruction 39 (3.0) Small bowel obstruction 32 (2.4) Dry/wet gangrene 29 (2.2) Acute pancreatitis 28 (2.1) Perforated viscus 26 (2.0) Malignant large bowel obstruction 26 (2.0) Cellulitis/skin infections 26 (2.0) Perianal abscess 22 (1.7) Pneumothorax 19 (1.4) Inquinal hernia 19 (1.4) Gastric outlet obstruction 18 (1.4) Incisional hernia 18 (1.4) Surgical wound infection 17 (1.3) Necrotising fasciitis 14 (1.1) Breast mass 13 (1.0) Abscess within the abdomen 13 (1.0) Mesenteric ischaemia (bowel 12 (0.9) necrosis) Ruptured abdominal aortic 11 (0.8) aneurysm Hydatid cyst 11 (0.8) Perforated appendix 10 (0.8) Perianal fistula 10 (0.8) Pilonidal sinus 8 (0.6) 8 (0.6) Breast abscess 8 (0.6) Multiple trauma injuries Others\* 109 (8.0)

Continued

# Table 3 Continued

Number of patients (n (n%))

\*Other diagnosis includes: umbilical hernia, foreign body within luminal compartment, lateral abdominal wall hernia, sigmoid volvulus, thyroid mass, infected foot ulceration, oesophageal obstruction, empyema, malignant small bowel obstruction, intussusception, acute peritonitis, Gunshot wounds, gluteal abscess, femoral hernia, haemothorax. ASA, American Society of Anesthesiology; AV, arteriovenous fistula.

Table 4	Emergency surgery	outcomes,	length o	f hospital
stay, post	operative complication	tions		

	Number of patients (n (n%))
Emergency surgery outcomes	
Patients reoperated within 30 days	115 (8.7)
Patients admitted to the ICU postoperatively	93 (7.0)
Patients who experienced one or more complications after surgery	178 (13.5)
Patients who were pronounced dead within 30 days of surgery	52 (3.9)
Length of hospital stay	
Less than 3 days	479 (36.2)
4 to 8 days	488 (36.9)
More than 9 days	355 (26.9)
Postoperative complications	
Superficial surgical wound infection	32 (2.4)
Deep surgical wound infection	20 (1.5)
Bleeding requiring transfusion	17 (1.3)
Cardiac arrest	14 (1.1)
Acute kidney injury	13 (1.0)
Organ/space surgical site infection	10 (0.8)
Sepsis	10 (0.8)
Haematoma	8 (0.6)
Deep vein thrombosis	7 (0.5)
Myocardial infarction	7 (0.5)
Ventilator requirement >48 hour	6 (0.5)
Wound dehiscence	6 (0.5)
Cardiac arrhythmia	5 (0.4)
Other complications *	23 (1.7)
Total number of patients	1322 (100)

\*Other complications include: acute cholangitis, anal fissure, paralytic ileus, pneumothorax, liver failure, common bile duct obstruction, cholecystolithiasis, pancreatitis, pleural fusion, peripheral nerve injury, bile leak, gallbladder polyps, enterocutaneous fistula. ICU, intensive care unit.



Figure 1 Mortality and morbidity according to age.

was previously determined for each patient as it is a part of the preoperative assessment protocol at our facility. The statistical analysis was two-tailed, and the significance threshold was set at 0.05 or less. The IBM SPSS Statistics V.26 was used, and the study was ethically approved by the institutional review board before the data collection commenced, waiving the need for patient consent while maintaining patient privacy

Patient and public involvement None

### RESULTS

A total of 1452 patients were admitted to the surgery ward in our institution for emergent surgery, and after excluding patients that did not meet our inclusion criteria, 1322 patients were enrolled. 52.6% of the patients were identified as men and 47.4% as women. The mean age of the population is 47.9 years old, with the youngest being 16 years old and the oldest patient admitted being 97 years old. 24.3% of the patients were over 60 years old. The distribution of the population based on age



Figure 2 Surgical approach comparison per ESS. ESS, Emergency Surgery Score.

ð was assessed and was well distributed in terms of gender uses (P value:0.968), ASA score (P value: 0.558), surgical approach (P value: 0.094), mortality (P value: 0.085) re and postoperative complication rate (0.200) and ICU ate admission (P value: 0.578). A vast majority of the patients were admitted through our emergency department, accounting for 91.9% of included patients, followed by text 6.8% of patients who were transferred from other hospitals, and 17 patients (1.3%) who were transferred to the surgery ward from other inpatient departments within KAUH. Less than half of the population underwent laparoscopic operations, and complication (95% CI: 0.793 to 0.858; P value: 0.0001) and mortality rates (95% CI: 0.922 to 0.959; P value: 0.001) were significantly lower compared **G** with patients who underwent open surgical techniques or  $\geq$ laparotomies (table 2); 27.2% of the population had been previously diagnosed with hypertension, and 20.7% had g diabetes, while 5.1% had diagnosed malignancies.

and More than half of the population were evaluated and given an ASA score of one, 24.1% had a score of two, 16.8% had a score of three and 7.4% of the population had a score of four or more. The diagnoses leading to admissions are described in table 3.

The most common diagnoses were acute cholecystitis no (26.2%), diabetic foot infection (8.2%) and obstructive jaundice (7.4%). The average length of hospital stay was **\overset{\circ}{\mathbf{B}}** 7 days; a median of 5 days (IQR. 3–9 days), with 36.2%of the patients spending less than 3 days, and 26.9% of patients spending more than 9 days. In addition, 93 (7%)patients were admitted to the ICU postoperatively, and 115 (8.7%) patients were reoperated for the same admitting diagnosis, or a complication of the surgery performed within 30 days of their first encounter (table 4).

3.9% of the population were pronounced dead within 30 days of the emergent surgery, and 13.5% of the population experienced postoperative complications. The

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#### ESS variables with respect to death rate and complications Table 5

		Morality ra	ite	Postoperat	ive complication rate
	Patients n		P-value (95% CI lower		P-value (95% CI lower
ESS variable	(n%)	n (n%)	to upper)	n (n%)	to upper)
Age >60 years	315 (23.8)	30 (9.5)	0.0001 (2.677 to 8.298)	66 (21)	0.0001 (1.515 to 2.961)
Jordanian/non-White	1322 (100)	52 (3.9)	*	178 (13.5)	*
Transfer from outside emergency department	90 (6.8)	6 (6.7)	0.160 (0.765 to 4.436)	21 (23.3)	0.009 (1.243 to 3.493)
Transfer from an inpatient facility	17 (1.3)	2 (11.8)	0.142 (0.745 to 15.032)	4 (23.5)	0.270 (0.645 to 6.203)
Ascites	18 (1.4)	1 (5.6)	0.517 (0.189 to 11.072)	11 (61.1)	0.0001 (4.091 to 27.983)
Body mass index (BMI) <20 Kg/ $\rm m^2$	25 (1.9)	2 (8)	0.258 (0.497 to 9.454)	7 (28)	0.041 (1.054 to 6.222)
Dyspnoea	32 (2.4)	1 (3.1)	0.639 (0.105 to 5.854)	8 (25)	0.055 (0.971 to 4.968)
Functional dependence	65 (4.9)	7 (10.8)	0.012 (1.405 to 7.520)	23 (35.4)	0.0001 (2.279 to 6.651)
History of chronic obstructive pulmonary disease (COPD)	4 (0.3)	0 (0)	0.852 (0.950 to 0.971)	1 (25)	0.440 (0.222 to 20.772)
Hypertension	360 (27.2)	32 (8.9)	0.0001 (2.592 to 8.147)	76 (21.1)	0.0001 (1.629 to 3.126)
Steroid use	18 (1.4)	1 (5.6)	0.517 (0.189 to 11.072)	6 (33.3)	0.025 (1.219 to 8.883)
Preoperative ventilator requirement >48 hours	5 (0.4)	2 (40)	0.642 (0.950 to 0.971)	3 (60)	0.202 (0.846 to 0.883)
Weight loss more than 10% in the last 6 months	11 (0.8)	0 (0)	0.014 (2.761 to 103.368)	0 (0)	0.02 (1.624 to 5.899)
History of disseminated cancer	67 (5.1)	5 (7.5)	0.118 (0.796 to 5.395)	20 (29.9)	0.0001 (1.706 to 5.117)
Albumin <3.0 U/L	114 (8.6)	18 (15.8)	0.0001 (3.525 to 11.892)	43 (37.7)	0.0001 (3.166 to 7.318)
Alkaline phosphatase >125 U/L	368 (27.8)	12 (3.3)	0.271 (0.399 to 1.485)	51 (13.9)	0.428 (0.738 to 1.486)
Blood urea nitrogen >40 mg/dL	317 (24)	30 (9.5)	0.0001 (2.653 to 8.223)	72 (22.7)	0.0001 (1.790 to 3.470)
Creatinine >1.2 mg/dL	242 (18.3)	28 (11.6)	0.0001 (3.273 to 10.126)	59 (24.4)	0.0001 (1.835 to 3.694)
International normalised ratio>1.5	62 (4.7)	17 (27.4)	0.0001 (6.893 to 25.361)	27 (43.5)	0.0001 (3.335 to 9.626)
Platelets <150×10 U/L	52 (3.9)	6 (11.5)	0.014 (1.411 to 8.538)	13 (25)	0.016 (1.167 to 4.270)
Aspartate aminotransferase >40 U/L	315 (23.8)	13 (4.1)	0.868 (0.563 to 2.028)	40 (12.7)	0.706 (0.628 to 1.336)
Sodium >145 mg/dL	21 (1.6)	7 (33.3)	0.0001 (5.371 to 36.258)	8 (38.1)	0.004 (1.672 to 10.023)
White cell counts ×10/L	280 (21.2)	23 (8.2)	0.0001 (1.406)	68 (24.3)	0.0001 (1.466 to 2.011)
Less than 4.5	25 (1.9)	1 (4)	0.718 (0.190 to 11.128)	1 (4)	0.310 (0.047 to 2.635)
More than 15 and less than 25	227 (17.2)	16 (7)	0.002 (1.413 to 4.964)	53 (23.3)	0.0001 (1.791 to 3.720)
More than 25	28 (2.1)	6 (21.4)	0.0001 (3.592 to 25.263)	14 (50)	0.0001 (3.936 to 18.239)

\*The race was constant within the whole population and defined as non-white Jordanians, receiving a zero score on the ESS.

most prevalent postoperative complication was superficial surgical wound infections (32 patients; 2.4%), followed by deep surgical wound infections (20 patients; 1.5%) and bleeding leading to blood transfusions postoperatively (17 patients;1.3%). Mortality and complication rates increased when older age groups were compared with younger ones, as shown in table 2 (figure 1).

There was a gradual increase in laparotomies and open surgery techniques as the ESS increased. Patients with scores below three had relatively higher utilisation of minimally invasive techniques compared with higher ESS score points, and patients with scores greater than 11 all underwent open versus laparoscopic surgeries.

Protected by copyright, including for uses related to text and data mining, AI training, and similar technolog (figure 2) Higher mortality and morbidity rates were associated with specific ESS variables, for instance, patients that presented with ascites, history of ascites, functional dependence, high INR, or elevated creatinine (table 5). It was also noticed that higher mortality and morbidity rates were found in patients transferred from other facilities.

Mortality rates increased as the ESS score increased (table 6). We observed that patients who scored two or less points had a mortality rate of 0.7%, while patients who scored more than eleven had a mortality rate 57%. The ESS was evaluated as a predictor of 30-day mortality based on a c-statistic of 0.842 (95% CI: 0.743 to 0.896)

	Neurolean of	Mortality				Postoperative complication			
	patients n			95% CI			OR	95% CI	
ESS	S (n%) P value	value OR L		Lower Upper P value			Lower	Upper	
)	261 (19.7)	-	1 (Reference)	-	-	-	1 (Reference)		-
	234 (17.7)	0.047	2.218	1.010	4.873	0.047	2.218	1.010	4.873
2	266 (20.1)	0.006	2.839	1.486	5.942	0.006	2.836	1.344	5.984
3	157 (11.9)	0.001	3.664	1.668	8.051	0.001	3.664	1.668	8.051
1	138 (10.4)	0.014	13.893	1.691	114.112	0.001	3.765	1.687	8.405
5	90 (6.8)	0.013	15.294	1.762	132.744	0.000	6.717	2.989	15.096
6	71 (5.4)	0.007	19.697	2.263	171.473	0.000	6.165	2.606	14.583
7	52 (3.9)	0.000	47.273	5.770	387.299	0.000	15.688	6.748	36.467
3	25 (1.9)	0.000	65.000	7.241	583.510	0.000	14.119	5.027	39.653
9	10 (0.8)	0.000	111.429	10.267	1209.319	0.000	58.567	13.161	260.618
10	10 (0.8)	0.000	260.000	25.494	2651.619	0.000	58.567	13.161	260.618
>11	8 (0.6)	0.000	260.000	23.504	2876.165	0.000	200.800	22.863	1763.608
z-score	_	0.000	1.652	1.484	1.84	0.000	1.415	1.327	1.509

Complication rates also increased with reciprocal raises in ESS points scored. It is noted that patients who scored less than three points had a complications rate of 8.3%, while patients that scored more than ten points had a complication rate of 83.3% (figure 4A,B). The ESS had a c statistic value of 0.724 (95% CI: 0.682 to 0.765), and the ASA had 0.670 (95% CI: 0.597 to 0.743) We also compared the ability of the ESS to predict specific complications and found that the ESS is a strong predictor of sepsis; C-statistic value of 0.928 (95% CI:0.876 to 0.981), cardiac arrhythmia; C-statistic value of 0.876 (95% CI: 0.765 to 0.988) and cardiac arrest; C-statistic value of 0.859 (95% CI: 0.797 to 0.920).

An increase in ICU admission was observed as the points scored on the ESS increased. The ICU admission rate for patients who scored below three was 2.4%, while for patients who scored higher than eight, the admission rate was 43.4% (figure 5A,B). The ESS was also evaluated as a predictor of ICU admission postoperatively with a C-statistic value of 0.825 (95% CI: 0.784 to 0.866) compared with ASA with C-statistic value of 0.703 (95% ē CI: 0.647 to 0.759). It is also noted that the frequency of patients who were reoperated on within 30-days increased as their respective scores increased. Patients who scored 6 three points or less had a reoperation rate of 6.5%, while patients who scored between four and nine had reoperation rates of 13.5% compared with patients who scored a more than 10 who had a reoperation rate of 16.7%. In addition, the patient's length of hospital stay increased as the ESS score increased. The majority of patients who scored zero and one spent less than 3 days in the hospital, while a majority of patients who scored more than nine ng, Al training, and points were admitted for more than 9 days (figure 6).

# DISCUSSION

The results of this study show that the ESS has a high predictive value for EGS 30-day mortality, morbidity, need similar technologies for ICU admission and risk of postoperative complications. These results appear to corroborate the findings of



Figure 3 (A) Postoperative death according to ESS, (B) comparison of receiver operator curves (ROC) between the ESS and ASA regarding postoperative death. ASA, American Society of Anesthesiology; ESS, Emergency Surgery Score.



Figure 4 (A) Postoperative complications according to ESS, (B) comparison of receiver operator curves (ROC) between the ESS and ASA regarding postoperative complication. ASA, American Society of Anesthesiology; ESS, Emergency Surgery Score.

previous studies that have attempted to validate the ESS. The overall trend being that a higher ESS correlates to a higher mortality rate, this risk becomes critical in our study, with an ESS score of seven or higher, where the mortality rate for an ESS between 7 and 10 and an ESS of 11 or higher are 21.6% and 57%, respectively. The incidence of ICU admissions correlated with the ESS similarly to the mortality rate, as a significant cut-off was found in our study at an ESS of eight, with ICU admissions for patients with an ESS less than eight and an ESS of eight or higher being 6.8% and 43.4%, respectively. These findings are congruent with the findings in the study by Kongkaewpaisan et al, where they proposed a cut-off ESS of seven or higher as grounds for ICU admission, as they found that only 6.2% of patients with ESS of seven or less had an ICU need, while 58.2% of patients with an ESS higher than seven had an ICU admission.<sup>15</sup>

It is important to note, however, that the ESS has a prognostic value even in low-risk patients with lower ESS values, as it was found to accurately predict the risk of re-operation, increased length of hospital stay and postoperative complications. The 30-day reoperation rate for patients with an ESS above three was double that of those with an ESS less than three. The length of hospital stay was also significantly longer for patients with an ESS of only two to four compared with those with an ESS of zero to one. The study by Alburakan et al found that the length of hospital stay was expected to increase by 2.7 days for each increase in ESS value of one.<sup>12</sup> We also found that the rate of complications for patients with an ESS of four to nine was also more than three times that of patients ßu with an ESS of less than three. These findings are in line ğ with the results in the study by Han et al, where postop**nse** erative infections developed in 7% and 24% of patients with an ESS of one and five, respectively.<sup>14</sup> This provides Ses re an added benefit for both the physician and patient, as it shows that even low-risk patients with low mortality risk and no need for ICU admission can be counselled objectively regarding their expected clinical course based on their ESS score.

Interestingly, we found that EGS procedures done for patients with an ESS of three or higher were predominantly done with a laparotomy incision, while EGS procedures for patients with an ESS of zero to two were well distributed between both approaches with a preponderance towards laparoscopy. While these findings are merely correlations, these results indicate that it may be possible to use the ESS to decide which EGS patients are fit for the use of laparoscopic technique, allowing the surgeon to avoid unnecessary laparotomies in a subgroup of EGS cases where minimally invasive alternatives may be used. Still, further evidence from future studies is needed



**Figure 5** (A) Postoperative intensive care unit (ICU) admission per ESS, (B) comparison of receiver operator curves (ROC) between the ESS and ASA regarding postoperative ICU admission. ASA, American Society of Anesthesiology; ESS, Emergency Surgery Score.





Figure 6 Duration of hospital stay comparison per ESS. ESS, Emergency Surgery Score.

to support or disprove this observation. The use of Laparoscopic techniques in EGS, when appropriate, leads to decreased postoperative pain, earlier mobilisation and reduces the need for negative laparotomies,<sup>23</sup> while also providing effective management in EGS cases that are hemodynamically stable and not in septic or haemorrhagic shock.<sup>24</sup>

We also compared the ESS to the ASA and found that it performed better than the ASA score in all parameters analysed. The ESS was found to be a strong predictor of 30-day mortality, morbidity and need for ICU admission. This is not to say that the ASA score is not predictive of patient outcomes, as our results clearly show that it is. Rather, our findings show the superiority of the ESS as a predictive tool when used in the setting of EGS. This may be due to the subjective nature of the ASA Score parameters, while in contrast the ESS takes more objective factors into account.

Compared with non-emergency general surgery, EGS has been shown to have a higher mortality rate, complication rate, and length of hospital stay.<sup>3</sup> The cost associated with emergency surgery is also more significant due to the more extended average hospital stay of patients, the need for ICU admission and the increased cost of management.<sup>25</sup> The increased cost can often be a hindrance to timely patient care, especially in underprivileged communities where the increased cost might result in the need for transfers to other facilities with better resources. This shows the critical nature of emergency surgery and the importance of efficient triaging to designate priority in terms of surgical interventions and the allocation of ICU beds, especially in underserved hospitals. The ESS being able to accurately predict the incidence of 30-day postoperative complications and the need for ICU admissions, in addition to the mortality rates, supports the validity of the ESS as an accessible and relevant tool for risk assessment in acute EGS settings. Furthermore, using the ESS may provide a more time-efficient manner by which surgical intervention priorities are assessed, and as a result, improved overall patient outcomes are achieved. In Jordan, studies on the availability of CT imaging according to the region and hospital are not available, but to our knowledge, there is a lack of medical

imaging services required to meet the demand of emergent medical and surgical needs. Therefore, we believe the ESS will also prove invaluable to smaller centres in underprivileged populations who may not have timely access to accurate imaging services, thereby improving overall outcomes.

Few studies have attempted to validate the ESS outside of the USA, this one being the first to provide insight on EGS in Jordan. The results of this study support the validity of the ESS in the Jordanian population and T further underscores the benefit of the ESS as a tool in EGS. KAUH is one of a small number of tertiary centres in Jordan and receives referrals from the whole region. ŝ This data sample is also well distributed between male and female patients, as well as between both laparoscopic opyrigh and open laparotomy approaches. Therefore, the data in this study are relatively representative of the outcome of using the ESS in the general population.

This study has a few limitations. First, the data for this study were collected retrospectively. Second, missing values were equated instead of excluding the patients from the data set. This was done to avoid excluding otherwise eligible patients because of missing values that were wise eligible patients because of missing values that were not collected due to them being low-risk patients and not requiring all of the investigations included in the ESS, thereby increasing the power of the study and avoiding bias. Thirdly, the data set collected had a small number of patients with an ESS above 11; therefore, findings in that subgroup of two patients in this study need further corrobe oration with larger cohorts to establish confidence in the generalisability of these findings. Fourthly, the heterogeneity of the diagnoses included in the study shows the extensive utility of the ESS. However, this heterogeneity might affect the perceived significance of the statistical results. Finally, our definition of emergency surgery and ing, Al training, and its protocols might differ from that of previous studies or what is practiced in other countries.

### CONCLUSION

The ESS outperformed the ASA score in the emergency surgery setting and was able to accurately predict the 30-day mortality rate, need for ICU admission, 30-day reoperation rate and length of hospital stay in a Jordatechnologies nian population. The ESS, therefore, appears to be a valuable and accessible tool for the preoperative assessment of EGS outcomes at the bedside.

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**Contributors** LR, SAA, TSM, KA were responsible for the conceptualisation and design of the study. LR, TSM, KA were responsible for project administration. SAA, NBA, MAAH, HAA, FSA did data collection. SAA was responsible for data analysis, tables' and figures' creation. SAA and NBA wrote and drafted the initial manuscript. LR, TSM, KA, GC and FI critically read the manuscript. All authors read, edited, proofread and approved the final manuscript before submission. LR and SAA both equally share the responsibility of a guarantor.

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**Data availability statement** Data are available upon reasonable request. The database created and analysed during this study is not publicly available as per patient privacy regulations of our hospital but is available from the corresponding author on reasonable request after blinding patient identifying information.

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